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(54) **Gas turbine**

(57) Gas turbine blade ring is cooled by steam of which temperature, pressure and flow rate are controlled so that clearance between moving blade tip and blade ring is maintained appropriately. Steam from steam turbine bottoming cycle (10) flows into blade ring cooling passage (8) of gas turbine (1) via piping (12) for cooling blade ring. The steam having cooled the blade ring is supplied into transition piece cooling passage (9) of combustor (3) for cooling transition piece and is then recovered into the steam turbine bottoming cycle (10) via piping (14). While the steam cools the blade ring, temperature, pressure and flow rate of the steam are controlled so that thermal elongation of the blade ring is adjusted and the clearance at the moving blade tip is controlled so as to approach target value. Thus, the clearance is maintained as small as possible in operation and gas turbine performance is enhanced.

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates generally to a gas turbine and more particularly to a gas turbine in which a blade ring, especially of first and second stages, is improved in the shape so as to have less thermal influences as well as the blade ring is cooled with less thermal expansion and uniform deformation by steam, of which temperature, pressure and flow rate are controlled, so that a clearance at a moving blade tip is reduced in operation, thereby enhancing a gas turbine performance.

Description of the Prior Art

[0002] Fig. 20 is a cross sectional view showing an interior of a representative gas turbine in the prior art. In Fig. 20, numeral 100 designates an outlet of a combustor transition piece, from which a high temperature combustion gas flows out. Numeral 101 designates a gas path, in which four stages of stationary blades 1C, 2C, 3C, 4C are arranged in an axial direction of the turbine. The stationary blades 1C, 2C, 3C, 4C are connected fixedly to blade rings 102, 103, 104, 105, respectively, via respective outer shrouds and each of the stationary blades 1C, 2C, 3C, 4C includes a plurality of blades arranged in a circumferential direction of the turbine along respective inner walls of the blade rings 102, 103, 104, 105. Also, moving blades 1S, 2S, 3S, 4S are arranged in the axial direction alternately with the stationary blades 1C, 2C, 3C, 4C and each of the moving blades 1S, 2S, 3S, 4S is connected fixedly to a rotor 200 and includes a plurality of blades arranged in the circumferential direction around the rotor 200.

[0003] In the gas turbine of the above-mentioned construction, cooling of the blade is usually done by air such that the stationary blade is fed with cooling air from the blade ring side and the moving blade is fed with cooling air from the rotor side. Accompanying with a recent higher temperature gas turbine, however, it is a tendency to employ a cooling system using steam. Also, at the time of start-up of the gas turbine, while there is maintained a predetermined clearance between a moving blade tip and a blade ring, the blade ring is still cold to shrink in the rise time and, on the other hand, the rotor and the moving blade are heated earlier. Hence, the clearance at the moving blade tip becomes smaller and a risk of contact in operation becomes higher. Accordingly, the clearance must be set appropriately taking this risk into consideration. If this clearance is too broad, it will reduce the gas turbine performance and thus to make the clearance between the moving blade tip and the blade ring as small as possible is an effective means to enhance the gas turbine performance. But it is still a present status that such countermeasure is not sufficiently established yet in the field of the industrial gas turbine.

[0004] As mentioned above, in the conventional industrial gas turbine, it is usual that cooling air is led into the gas turbine stationary blade, moving blade, rotor, etc. for cooling thereof. But, in the recent tendency to employ a higher temperature gas turbine, a steam cooling system is being used in place of the air cooling system. In such a gas turbine, the clearance between the moving blade tip and the blade ring changes due to thermal influences in the operation beginning from the start-up time and the predetermined clearance at the start-up time becomes the minimum clearance state caused by a thermal elongation difference between the blade ring and the moving blade in the rise time, so that a contact may arise to invite a dangerous state unless an appropriate setting of the clearance is ensured. Also, if the clearance is too large in operation, it will invite a reduction in the gas turbine performance and so the appropriate setting of the tip clearance of the moving blade becomes necessary. For this purpose, it is preferable to make the tip clearance not much changeable by heat as well as to make the tip clearance optimally controlled so as not to cause a contact but, while such control is being variously studied, it is a present status that a sufficient art therefor is not established yet in the field of the industrial gas turbine.

SUMMARY OF THE INVENTION

[0005] In view of the mentioned problem in the prior art, it is an object of the present invention to provide a gas turbine in which a gas turbine blade ring is improved in the structural shape so as to have less thermal influences as well as the blade ring is made with a cooling system using steam of which temperature, pressure and flow rate are controlled so that a clearance between a moving blade tip and the blade ring may be set optimally.

[0006] In order to achieve the mentioned object, the present invention provides means of the following (1) to (15):

(1) A gas turbine comprising a moving blade and a blade ring confronting a tip of the moving blade, characterized in that a cooling passage is provided in the blade ring and an auxiliary boiler and a steam supply source connecting to a steam turbine bottoming cycle are connected to the cooling passage, so that steam of the auxiliary boiler or the steam supply source is flown into the cooling passage for cooling the blade ring and the steam having cooled the blade ring is recovered, and thereby a clearance between the tip of the moving blade and the blade ring is reduced.

(2) A gas turbine comprising a moving blade and a blade ring confronting a tip of the moving blade as well as comprising a combustor and a transition piece contained in the combustor, characterized in

that a cooling passage is provided in the blade ring, so that steam of a steam supply source is flown into the cooling passage for cooling the blade ring and the steam having cooled the blade ring is flown into the transition piece via a combustor transition piece connection portion for cooling a wall interior of the transition piece and the steam having cooled the wall interior of the transition piece is recovered into the steam supply source, and thereby a clearance between the tip of the moving blade and the blade ring is reduced.

(3) A gas turbine comprising a moving blade and a blade ring confronting a tip of the moving blade as well as comprising a combustor and a transition piece contained in the combustor, characterized in that a cooling passage is provided in the blade ring, so that steam of a steam supply source is flown in parallel into the cooling passage for cooling the blade ring and into the transition piece via a combustor transition piece connection portion for cooling a wall interior of the transition piece and the steam having cooled the blade ring and the wall interior of the transition piece is recovered into the steam supply source, and thereby a clearance between the tip of the moving blade and the blade ring is reduced.

(4) A gas turbine comprising a first stage stationary blade and a first stage moving blade and a blade ring confronting a tip of the first stage moving blade as well as comprising a combustor and a transition piece contained in the combustor, characterized in that a blade ring cooling passage is provided in the blade ring and a stationary blade cooling passage is provided in the first stage stationary blade so as to connect to the blade ring cooling passage, so that steam of a steam supply source is flown into the blade ring cooling passage for cooling the blade ring and the steam having cooled the blade ring is flown into the stationary blade cooling passage for cooling the first stage stationary blade and the steam having cooled the first stage stationary blade is flown into the transition piece via a combustor transition piece connection portion for cooling a wall interior of the transition piece and the steam having cooled the wall interior of the transition piece is recovered into the steam supply source, and thereby a clearance between the tip of the first stage moving blade and the blade ring is reduced.

(5) A gas turbine comprising a first stage stationary blade and a first stage moving blade and a blade ring confronting a tip of the first stage moving blade as well as comprising a combustor and a transition piece contained in the combustor, characterized in that a blade ring cooling passage is provided in the blade ring and a stationary blade cooling passage is provided in the first stage stationary blade so as to connect to the blade ring cooling passage, so that steam of a steam supply source is flown in parallel into the blade ring cooling passage for cooling the blade ring and into the stationary blade cooling passage for cooling the first stage stationary blade and the steam having cooled the first stage stationary blade is flown into the transition piece via a combustor transition piece connection portion for cooling a wall interior of the transition piece and the steam having cooled the blade ring and the wall interior of the transition piece is recovered into the steam supply source, and thereby a clearance between the tip of the first stage moving blade and the blade ring is reduced.

(6) A gas turbine as mentioned in (2) above, characterized in that the blade ring is a blade ring confronting a tip of a first stage moving blade, the combustor is a plurality of combustors arranged in a turbine circumferential direction, there are provided in the blade ring a plurality of blocks protruding in a turbine axial direction from positions of the blade ring corresponding to positions of the plurality of combustors and, in each of the plurality of blocks, there is provided a U-shape passage formed by turbine axial directional and circumferential directional passages, so that steam is flown into the U-shape passage from one end of the U-shape passage for cooling the blade ring and is flown out of the other end of the U-shape passage, and the steam having cooled the blade ring is supplied into the transition piece via the combustor transition piece connection portion.

(7) A gas turbine as mentioned in (2) above, characterized in that the blade ring comprises a first blade ring confronting a first stage moving blade and a second blade ring confronting a second stage moving blade, the cooling passage comprises a first cooling passage formed in the first blade ring and a second cooling passage formed in the second blade ring and there are provided a turbine axial directional passage for connecting the first and second cooling passages to each other and a transition piece side passage for connecting the first cooling passage and the combustor transition piece connection portion to each other, so that the steam of the steam supply source is flown sequentially in the second cooling passage, turbine axial directional passage, first cooling passage and transition piece side passage and is then supplied to the combustor transition piece connection portion.

(8) A gas turbine as mentioned in (7) above, characterized in that the combustor transition piece connection portion comprises a transition piece cooling inlet connecting to the first cooling passage, a transition piece cooling outlet through which the steam having cooled the transition piece flows out and an outlet pipe manifold connecting to the transition piece cooling outlet.

(9) A gas turbine as mentioned in (7) above, characterized in that each of the first and second blade

rings is formed such that upper and lower two separated semicircular portions of the blade ring are joined together at flanges provided on both side surface portions of the blade ring, there are provided a recessed portion or a protruded portion on an outer circumferential surface portion of the blade ring so as to fit to or fit in a portion of a turbine casing inner wall and another protruded portion on an inner circumferential surface portion of the blade ring so as to support a wall surface confronting the tip of the moving blade and a turbine axial directional cross sectional shape of the blade ring is approximately symmetrical relative to a turbine radial directional central axis in the turbine axial directional cross sectional shape of the blade ring.

(10) A gas turbine as mentioned in (7) above, characterized in that each of the first and second blade rings is formed such that upper and lower two separated semicircular portions of the blade ring are joined together at flanges provided on both side surface portions of the blade ring and, in horizontal surface portions of the upper and lower semicircular portions of the blade ring so joined at the flanges, the cooling passage provided in the upper semicircular portion of the blade ring is extended so as to be inserted with a predetermined length into the cooling passage provided in the lower semicircular portion of the blade ring and a sealing material is interposed around the cooling passage so extended of the upper semicircular portion of the blade ring.

(11) A gas turbine as mentioned in any one of (1) to (5) above, characterized in that the blade ring is formed such that upper and lower two separated semicircular portions of the blade ring are joined together at flanges provided on both side surface portions of the blade ring and there are provided members, having masses substantially equivalent to the flanges thermally, on upper and lower portions of an outer circumferential surface portion of the blade ring.

(12) A gas turbine as mentioned in any one of (1) to (5) above, characterized in that the blade ring is provided with a plurality of steam inlets and steam outlets, respectively, arranged substantially evenly in vertical and horizontal directions on an outer circumferential surface portion of the blade ring.

(13) A gas turbine as mentioned in (7) above, characterized in that the blade ring is applied to on its surface exposed to a high temperature space with a thermal shield made of a heat insulation material.

(14) A gas turbine as mentioned in any one of (1) to (5) above, characterized in that the blade ring is provided therein with a plurality of sensors for sensing the clearance at the tip of the moving blade, the sensors being inserted from outside of a turbine casing to pass through the turbine casing and the blade ring so that sensing portions of the sensors may be exposed on an inner circumferential wall surface confronting the tip of the moving blade, and there are provided a steam temperature controller arranged in a route for supplying the blade ring with steam from the steam supply source, a steam flow control valve arranged between the steam temperature controller and a steam inlet of the blade ring and a control unit taking signals from the sensors for comparison with a predetermined target value and controlling the steam temperature controller and an opening of the steam flow control valve so that the clearance may be approached to the target value.

(15) A gas turbine as mentioned in (14) above, characterized in that the sensors are FM electrostatic capacity type sensors.

[0007] The present invention is based on the inventions mentioned in (1) to (5) above. In the invention (1), firstly at the start-up time, steam from the auxiliary boiler is supplied into the cooling passage of the blade ring so that the blade ring which is cold during the rise time is heated and the clearance at the moving blade tip is enlarged and thereby a contact in the minimum clearance during the rise time can be avoided. In the ordinary operation time, steam from the steam turbine bottoming cycle is supplied into the blade ring to cool the portion of the blade ring confronting the moving blade tip and, by setting the temperature, pressure and flow rate of the steam appropriately, thermal elongation of the blade ring is controlled so that the clearance at the moving blade tip may be set correctly and thereby the gas turbine performance is prevented from being reduced by enlargement of the clearance.

[0008] In the invention (2), the blade ring is first cooled and the clearance at the moving blade tip can be controlled appropriately. And then the steam which has cooled the blade ring is flown into the combustor transition piece to flow in the high temperature wall interior of the transition piece for cooling thereof and is recovered thereafter. Thus, the control of the clearance is carried out and the cooling of the transition piece by steam is also carried out, thereby contributing in the enhancement of the gas turbine performance.

[0009] In the invention (3), steam supply to the blade ring and that to the transition piece are done in parallel and the same effect as that of the invention (2) can be obtained. Further, there is no need to provide a steam supply passage from the blade ring to the transition piece but the steam is supplied into the transition piece independently and thereby the applicability of the cooling system is broadened and an appropriate cooling system can be selected according to the types of the gas turbine.

[0010] In the invention (4), the steam first cools the blade ring and then cools the stationary blade and the steam which has been temperature-elevated by the cooling cools the transition piece which is a high tem-

perature portion. Thus, not only the blade ring is cooled and the clearance at the moving blade tip is controlled but also the stationary blade and the transition piece are cooled, thereby contributing in the enhancement of the gas turbine performance.

[0011] In the invention (5), steam supply to the blade ring and the stationary blade and that to the transition piece are done in parallel and the same effect as that of the invention (4) can be obtained. Further, the cooling system is made such that the steam supply to the transition piece can be done by a separate system and thereby the applicability of the cooling system is broadened and an appropriate cooling system can be selected according to the types of the gas turbine.

[0012] In the invention (6), the blade ring of the invention (2) is only the blade ring of the first stage which receives the severest thermal influence and the cooling passage is formed by the U-shape passage in each of the blocks arranged corresponding to positions of the combustors. Thereby, inflow of the cooling steam to the transition piece and outflow therefrom of the cooling steam having cooled the transition piece both via the combustor transition piece connection portion are facilitated and the structure therefor can be also simplified.

[0013] In the invention (7), the blade ring of the invention (2) is divided into the first and second blade rings and the first and second blade rings are provided with the first and second cooling passages, respectively. Thereby, the clearances at the tips of the first stage and second stage moving blades, respectively, can be controlled by the steam-cooling of the blade rings and the performance of the gas turbine of the invention (2) can be enhanced further effectively.

[0014] In the invention (8), supply of the cooling steam into the transition piece mentioned in the invention (7) is done easily through the transition piece cooling inlet of the combustor transition piece connection portion and also the cooling steam having cooled the transition piece is taken out easily through the transition piece cooling outlet so as to be collected in the outlet pipe manifold and thereby the recovery of the steam can be done easily into the steam supply source from the outlet pipe manifold.

[0015] In the invention (9), the cross sectional shape of the blade ring is approximately symmetrical relative to the radial directional central axis thereof so as to be compact in shape and the fitting of the blade ring with the turbine casing inner wall is done easily via the recessed or protruded portion and thereby the deformation quantity of the blade ring can be made smaller and equalized. Further, by making the blade ring cross sectional shape compact, the fitting portion with the turbine casing is simplified and the diameter of the turbine casing in this area can be made smaller. Also, in the invention (10), at the flange connection portion of the upper and lower semicircular portions of the blade ring, the sealing material is interposed around the extended cooling passage of the upper semicircular portion of the blade ring and thereby steam leakage in this portion can be prevented. Also, in the invention (11), the members having the thermal balancing masses substantially equivalent to the flanges on both of the side surfaces of the blade ring are provided on the upper and lower portions of the blade ring and thereby distortion of the blade ring caused by heat can be made uniform and occurrence of unusual thermal stresses can be prevented. Also, in the invention (12), the steam inlets and steam outlets of the blade ring are arranged evenly as much as possible in the vertical and horizontal directions and thereby the thermal deformation is balanced and the thermal deformation quantity is made uniform. Also, in the invention (13), the thermal shield is applied to the surface of the blade ring exposed to the high temperature gas and thereby the thermal influences given on the blade ring can be lessened.

[0016] In the invention (14), the basic inventions of (1) to (5) above are added with the sensors provided circumferentially in the blade ring for sensing the clearances at the tip of the moving blade and the signals of the clearances so sensed are inputted into the control unit. The control unit compares the clearance signals so sensed with the target value which is stored in advance and controls the steam temperature by the steam temperature controller and also controls the opening of the flow control valve so that the clearances may approach to the target value. By so controlling, the steam temperature, pressure and flow rate can be adjusted easily, the clearances are set to the target value and the gas turbine performance can be prevented from being reduced. Further, in the invention (15), the FM electrostatic capacity type sensor is used and thereby the clearance can be detected precisely even in the high temperature state in the range of 0 to 5 mm.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] Fig. 1 is a constructional view of a gas turbine of a first embodiment according to the present invention.

[0018] Fig. 2 is a constructional view of a gas turbine of a second embodiment according to the present invention.

[0019] Fig. 3 is a schematic cross sectional view showing a blade ring cooling structure and a cooling steam passage of the gas turbine of the second embodiment of Fig. 2.

[0020] Fig. 4 is a partially cut-out perspective view showing the blade ring cooling structure and cooling steam passage of the gas turbine of the second embodiment of Fig. 2.

[0021] Fig. 5 is a system diagram showing another example of the blade ring cooling structure of the gas turbine of the second embodiment of Fig. 2.

[0022] Fig. 6 is a cross sectional view showing a concrete structure of the blade ring cooling system of Fig. 5.

[0023] Fig. 7 is an enlarged view showing a shape of a second blade ring described with respect to Figs. 5

and 6.

[0024] Fig. 8 is an enlarged view showing shapes of a turbine casing and the second blade ring described with respect to Fig. 6.

[0025] Fig. 9 is a partial cross sectional view of a flange connection portion of the blade ring, wherein Fig. 9(a) shows a prior art example of the blade ring and Fig. 9(b) shows a representative example of the second blade ring of Fig. 5.

[0026] Fig. 10 is a schematic view showing a further improvement, having thermal balancing masses, in the blade ring of the second embodiment described with respect to Figs. 5 and 6, wherein Fig. 10(a) is a front view of the blade ring and Fig. 10(b) is a side view of the blade ring.

[0027] Fig. 11 is a front view of the blade ring, having steam inlets and steam outlets, of the second embodiment described with respect to Figs. 5 and 6, wherein Fig. 11(a) shows an example having two steam inlets and four steam outlets and Fig. 11(b) shows an example having three steam inlets and three steam outlets.

[0028] Fig. 12 is a cross sectional view of a first blade ring, having a thermal shield, of the second embodiment described with respect to Figs. 5 and 6.

[0029] Fig. 13 is a constructional view of a gas turbine of a third embodiment according to the present invention.

[0030] Fig. 14 is a constructional view of a gas turbine of a fourth embodiment according to the present invention.

[0031] Fig. 15 is a constructional view of a gas turbine of a fifth embodiment according to the present invention.

[0032] Fig. 16 is a view showing clearance characteristic curves for explaining a clearance control system applicable to the first to fifth embodiments according to the present invention.

[0033] Fig. 17 is a cross sectional view of a gap sensor applicable to the clearance control system described with respect to Fig. 16.

[0034] Fig. 18 is a front view of the blade ring including a cross sectional view taken on line A-A of Fig. 17.

[0035] Fig. 19 is a control diagram of the clearance control system described with respect to Fig. 16.

[0036] Fig. 20 is a cross sectional view showing an interior of a representative gas turbine in the prior art.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0037] Herebelow, embodiments according to the present invention will be described concretely with reference to figures.

[0038] Fig. 1 is a constructional view of a gas turbine of a first embodiment according to the present invention. In Fig. 1, numeral 1 designates a gas turbine, numeral 2 designates a compressor and numeral 3 designates a combustor. In the gas turbine 1, there is provided a blade ring cooling passage 8. Cooling steam coming from a steam turbine bottoming cycle 10 is supplied into the blade ring cooling passage 8 via a piping 6 for cooling a blade ring and the steam after used for the cooling and heated is returned to be recovered into the steam turbine bottoming cycle 10 via a piping 7. Also, at the rise time, steam of an appropriate temperature coming from an auxiliary boiler 11 is supplied into the blade ring cooling passage 8 via a piping 4 for cooling the blade ring and the steam after used for the cooling is recovered into the auxiliary boiler 11 via a piping 5. The blade ring is so cooled by steam and thereby thermal elongation changes of the blade ring are adjusted so that a clearance between the blade ring and a moving blade may not be enlarged.

[0039] Fig. 2 is a constructional view of a gas turbine of a second embodiment according to the present invention, wherein a cooling system of a gas turbine blade ring and that of a gas turbine combustor transition piece are connected in series to each other. In Fig. 2, cooling steam coming from a steam turbine bottoming cycle 10 is first supplied into a blade ring cooling passage 8 via a piping 12 for cooling the blade ring and the steam after used for the cooling enters a transition piece cooling passage 9 of a combustor 3 via a piping 13 for cooling the transition piece and the steam having cooled the transition piece is recovered into the steam turbine bottoming cycle 10 via a piping 14.

[0040] Fig. 3 is a schematic cross sectional view showing a blade ring cooling structure and a cooling steam passage of the gas turbine of the second embodiment of Fig. 2, wherein a steam-cooling is applied to the blade ring of a first stage moving blade which receives the severest thermal influence in the gas turbine and the steam having cooled the blade ring is flown into the transition piece for cooling thereof.

[0041] In Fig. 3, there is provided a blade ring 20 of the gas turbine, being fixed to a turbine casing inner wall and surrounding a first stage moving blade 1S. A steam inlet 21 is provided in the blade ring 20 and cooling steam flows through the steam inlet 21 to be supplied into the blade ring 20 via the piping 12. The cooling steam supplied into the blade ring 20 flows through the blade ring cooling passage 8 for cooling the blade ring 20 and the steam having cooled the blade ring 20 flows through the piping 13 to be led into the transition piece cooling passage 9 of the combustor 3. The steam having cooled the transition piece is recovered via a piping which is not shown.

[0042] Fig. 4 is a partially cut-out perspective view showing a cooling structure of the blade ring 20, which confronts the first stage moving blade 1S, of the gas turbine of the second embodiment of Fig. 2. In Fig. 4, there is provided a steam supply pipe 25 along an inner circumferential wall of the blade ring 20. The blade ring 20 as illustrated here shows only a semi-circular upper half portion thereof, wherein there are provided one steam inlet 21 and two steam outlets 24 and the steam inlet 21 and each of the steam outlets 24 are connected with the

steam supply pipe 25 and a steam recovery pipe 26, respectively. The steam supply pipe 25 bifurcates from the steam inlet 21 toward both side directions thereof and the pipe diameter thereof becomes gradually smaller toward downstream of the steam supply pipe 25. The reason for that is to maintain a uniformity in the steam flow pressure in the pipe as the steam flow rate becomes less toward the downstream side when the steam is supplied to a plurality of blade ring cooling portions 22, each being formed in a block shape.

[0043] Also, on the reverse side of the member of the blade ring cooling portion 22, there is formed a transition piece cooling system connection portion 23 and this transition piece cooling system connection portion 23 is arranged in eight pieces circumferentially on the transition piece side of the blade ring 20 so as to position correspondingly to each of the combustors. In the transition piece cooling system connection portion 23, there are provided a hole 27 which connects to a steam inflow port of the transition piece and a hole 28 which connects to a steam outflow port of the transition piece.

[0044] In the cooling structure shown in Fig. 4, cooling steam flows in from the steam inlet 21 and, being bifurcated toward both sides thereof, enters respectively the blade ring cooling passage 8 of the blade ring cooling portion 22. The blade ring cooling passage 8 comprises two passages 8a arranged in the axial direction of the turbine and a passage 8b arranged in the circumferential direction of the turbine and when the cooling steam flows therethrough, it cools the circumferential wall surface portion, confronting the moving blade, of the blade ring 20.

[0045] The cooling steam flows through the blade ring cooling passage 8 from one of the passages 8a to the passage 8b and further to the other of the passages 8a and then flows through the hole 27 of the transition piece cooling system connection portion 23 to enter the transition piece of the combustor (not shown) for cooling thereof. The steam having cooled the transition piece returns to the hole 28 of the transition piece cooling system connection portion 23 from the transition piece and then flows into the steam recovery pipe 26 to be recovered through the steam outlet 24.

[0046] Thus, in the gas turbine of the present second embodiment, the blade ring, confronting the moving blade, is cooled by steam so as to suppress thermal influences and, by controlling flow rate, pressure and temperature of the steam appropriately, contact at the clearance portion between the blade ring and the moving blade tip is prevented and the clearance is maintained as small as possible in operation. Also, the steam having cooled the blade ring 20 is flown into the transition piece of the combustor 3, which is of a higher temperature, and thereby the transition piece is cooled effectively and the gas turbine performance can be enhanced.

[0047] Fig. 5 is a system diagram showing another example of the blade ring cooling structure of the gas turbine of the second embodiment of Fig. 2. In this example, independent blade rings confronting the first stage moving blade and the second stage moving blade, respectively, are provided, that is, the structure is made such that the conventional blade ring, made in an integral structure, is separated so that the respective blade rings are featured in the shape having less thermal influences.

[0048] In Fig. 5, cooling steam coming from a boiler first flows into a second blade ring 31 for cooling thereof and then flows into a first blade ring 30 for cooling thereof. The steam having cooled the first and second blade rings 30, 31 flows into a transition piece cooling inlet 32 to flow through a wall interior of the transition piece for cooling the transition piece. The steam having cooled the transition piece flows into an outlet pipe manifold 34 through a transition piece cooling outlet 33 and is recovered into a steam turbine.

[0049] Fig. 6 is a cross sectional view showing a concrete structure of the blade ring cooling system shown in Fig. 5. In Fig. 6, the first blade ring 30 and the second blade ring 31 are separated from each other and the first blade ring 30 confronts the first stage moving blade IS and the second blade ring 31 confronts the second stage moving blade 2S. In the blade rings 30, 31, along the circumferential central portion thereof, there are provided blade ring cooling passages 35, 36, respectively, and the first blade ring 30 and the second blade ring 31 are connected to each other with three passages arranged in the axial direction of the turbine, as schematically shown in Fig. 5.

[0050] The blade ring cooling passage 35 in the first blade ring 30 is connected to the transition piece cooling inlet 32 with a plurality of passages 38 arranged in the axial direction and steam is supplied into a wall interior of the transition piece through the passages 38 and the transition piece cooling inlet 32. The steam having cooled the transition piece flows through the transition piece cooling outlet 33 and a piping 39 and further through the outlet pipe manifold 34 and is returned to a steam turbine. Also, on the circumferential surfaces and on both side surfaces thereof of the first and second blade rings 30, 31, respectively, there are provided thermal shields 37, so that the blade rings 30, 31 may be shielded from heat transferring in the axial direction.

[0051] Fig. 7 is an enlarged view showing the second blade ring 31 described with respect to Figs. 5 and 6. The second blade ring 31 is constructed such that the conventional blade ring 103 is separated into two parts so that one of the parts constitutes the second blade ring 31 and the blade ring cooling passage 36 is formed in the second blade ring 31 along the circumferential interior central portion thereof. The second blade ring 31 comprises a recessed portion 31a which fits to a portion of the turbine casing wall and another recessed portion 31b which constitutes a fitting portion on the moving blade side and these recessed portions 31a, 31b, respectively, are formed approximately in a front and rear symmetrical shape relative to the turbine radial direc-

tional central axis of the second blade ring 31 in Fig. 7. By employing such construction of the central axis symmetry, the blade ring can be made compact in the shape and deformation quantity around the central axis can be made uniform.

[0052] The first blade ring 30 is also made in the substantially same construction and description thereon will be omitted. By employing the first and second blade rings 30, 31 constructed as mentioned above, the deformation quantity around the central axis thereof can be made uniform and less as compared with the conventional blade ring 103. It is to be noted that while the recessed portion 31a for fitting with the turbine casing wall is formed to be recessed toward the blade ring side in the illustration, this may be reversed, that is, the turbine casing side is recessed and the blade ring side is protruded, so that the same central axis symmetry may be achieved.

[0053] Fig. 8 is an enlarged view showing the turbine casing portion and the blade ring portion shown in Fig. 6. In Fig. 8, the first and second blade rings 30, 31 are made compact in size and the steam cooled structure is employed and thereby a turbine casing 40 can be made smaller as compared with a conventional turbine casing 150. Also, the fitting portion with the turbine casing wall is moved toward the inner side of the turbine so that the turbine casing outer diameter may be made smaller and rigidity against thrust forces of the blade rings 30, 31 can be enhanced as compared with the conventional case. In Fig. 8, numeral 30a designates a first ring segment, which is a comparatively thin member fixed to the lower portion of the first blade ring 30 between the first blade ring 30 and the corresponding blade tip. Numeral 31a designates a second ring segment, which is formed and arranged, like the first ring segment 30a, between the second blade ring 31 and the corresponding blade tip. The clearance or gap between the blade ring and the blade tip is actually that between the ring segment and the corresponding blade tip.

[0054] Fig. 9 is a cross sectional view of a flange connection portion of upper half and lower half portions of the blade ring and Fig. 9(a) shows a conventional example of the blade ring 103 and Fig. 9(b) shows a representative example of the second blade ring 31 of the second embodiment according to the present invention. As described with respect to Fig. 7, the blade ring 31 is structured so as to mitigate local stresses by making the blade ring 31 in the central axis symmetrical shape and making the thickness uniform and also a flange 41 of the blade ring 31 is made thinner as compared with a flange 151 of the conventional example. By employing such construction, both of the turbine axial directional and circumferential directional deformation quantity can be made uniform. Further, the blade ring cooling passage 36 at the flange connection portion is connected via a connection portion 42 and a seal 43 is interposed around the connection portion 42.

[0055] Fig. 10 is a schematic view showing a further improvement in the blade ring of the second embodiment as described with respect to Figs. 5 and 6, taking example of the first blade ring 30, and Fig. 10(a) is a front view of the blade ring and Fig. 10(b) is a side view of the same. In Figs. 10(a) and (b), the upper half and lower half portions of the first blade ring 30 are fixed to each other via the horizontal flanges 41 provided on both sides of the blade ring 30 and steam flows in the first blade ring 30 for cooling thereof and then flows into the transition piece of the combustor 3 for cooling thereof and is recovered. On the top and bottom of the blade ring 30, there are provided thermal balancing masses 44. The thermal balancing masses 44 have the equivalent masses to the horizontal flanges 41 so that the weight and shape may be made equivalent in the vertical and horizontal directions and thereby thermal changes may be balanced in the same directions.

[0056] Fig. 11 is a front view of the second blade ring 31 of the second embodiment described with respect to Figs. 5 and 6, showing examples of arrangements of the steam inlet and outlet for effecting uniform and even thermal changes and Fig. 11(a) shows an example where two steam inlets and four steam outlets are arranged and Fig. 11(b) shows an example where three steam inlets and three steam outlets are arranged. In Fig. 11(a), the steam inlet through which steam enters the blade ring 31 is arranged as two steam inlets 45-1, 45-2 at the top and bottom of the blade ring 31 and the steam outlet through which the steam flows out of the blade ring 31 is arranged as four steam outlets, that is, two 46-1, 46-2 on the right hand side and two 46-3, 46-4 on the left hand side of the blade ring 31 and the construction is made such that the arrangement of the steam inlets and outlets is balanced so as to realize a uniform and even cooling by steam, suppressing imbalances in the thermal deformation.

[0057] The example of Fig. 11(b) is for the case where a larger flow rate of the steam is needed and the steam inlet is arranged as three steam inlets, that is, one 47-1 on the top and two 47-2, 47-3 on the lower side of the blade ring 31 and the steam outlet is arranged also as three steam outlets, that is, two 48-1, 48-3 on the upper side and one 48-2 on the lower side of the blade ring 31. Thereby, the flow of the steam is made uniform, cooling of the blade ring by steam is equalized and the thermal deformation quantity can be made uniform.

[0058] Fig. 12 is a cross sectional side view of the first blade ring 30 of the second embodiment described with respect to Figs. 5 and 6, showing a concrete example of the thermal shield. In Fig. 12, a thermal shield 37 is provided mainly on the front and rear side surfaces of the blade ring 30 which face to the turbine axial direction. The thermal shield 37 is fitted to the surfaces of the blade ring 30 such that a heat insulating material 49 is fixed to the surfaces by a bolt 51 and a cover 50 is applied to surfaces of the heat insulating material 49. By so applying the thermal shield 37 on the circumferential front and rear side surfaces of the blade ring 30, the

blade ring 30 is shielded from a high temperature heat transferring in the turbine axial direction and the effect of the steam-cooling is enhanced.

[0059] In the second embodiment as described above with respect to Figs. 2 to 12, the cooling system is so made that the blade ring 20 is cooled by steam or the second blade ring 31 is first cooled and the first blade ring 30 is then cooled by steam and the steam having cooled the blade ring cools the transition piece and also the construction is so made that the blade ring 30, 31 is made compact in the central axis symmetrical shape and the thermal shield 37 is applied as well as the thermal balancing mass 44 is fitted to the blade ring 30, 31 so as to ensure a balance in the thermal changes or the arrangement of the steam inlet and outlet of the blade ring 30, 31 is balanced in the vertical and horizontal directions of the blade ring 30, 31 so as to ensure a uniform cooling effect. By employing such construction, the blade ring confronting the moving blade is cooled effectively by steam and, by controlling the temperature, pressure and flow rate of the steam, the clearance at the moving blade tip is prevented from contacting at the rise time and also the clearance is maintained as small as possible during the operation. Thus, the gas turbine performance can be enhanced.

[0060] Next, Fig. 13 is a constructional view of a gas turbine of a third embodiment according to the present invention. In Fig. 13, what is different from the second embodiment shown in Fig. 2 is that, while the second embodiment employs a series cooling system in which cooling steam first cools the blade ring of the gas turbine 1 and then cools the transition piece of the combustor 3, in the present third embodiment, the blade ring cooling passage 8 of the gas turbine 1 and the transition piece cooling passage 9 of the combustor 3 are connected in parallel to each other and the cooling steam flows into them concurrently. Other portions of the construction are same as those of the second embodiment shown in Fig. 3.

[0061] In Fig. 13, cooling steam coming from the steam turbine bottoming cycle 10 flows in parallel into the transition piece cooling passage 9 of the combustor 3 via a piping 17 and into the blade ring cooling passage 8 of the gas turbine 1 via a piping 15, respectively, and the steam after used for the cooling flows from the transition piece via a piping 18 and from the blade ring via a piping 16 to be both recovered into the steam turbine bottoming cycle 10. It is to be noted that, as to the present third embodiment also, except the blade ring cooling structure in which the cooling steam having cooled the blade ring is not supplied into the transition piece but is recovered as it is, the same concrete constructions shown in Figs. 3 to 12 may be applied to the third embodiment as they are and, in this case also, the same effect of the invention can be obtained.

[0062] Fig. 14 is a constructional view of a gas turbine of a fourth embodiment according to the present invention, wherein the cooling system of the blade ring and the transition piece is made such that cooling steam first cools the blade ring, which confronts the first stage moving blade 1S, and then cools the first stage stationary blade 1C and the steam further flows into the transition piece for cooling thereof and is then recovered.

[0063] In Fig. 14, cooling steam is led from a steam turbine bottoming cycle (not shown), like in Figs. 1 and 2, via a passage 61 and enters a portion 60a, confronting the first stage moving blade 1S, of a blade ring 60 for cooling thereof. Cooling of this portion 60a, like in the example shown in Fig. 4, may be done by a cooling passage formed in a U-shape by the turbine axial directional and radial directional passages. The steam having cooled the portion 60a of the blade ring 60 flows into the first stage stationary blade 1C for cooling thereof via a passage 62 and then flows into the transition piece of the combustor 3 for cooling thereof via a passage 63 and is thereafter recovered via a passage 64.

[0064] In the fourth embodiment described above, like in the second embodiment, the blade ring is cooled by steam so that the clearance between the blade ring and the moving blade 1S may be adjusted to an appropriate gap as well as the transition piece is cooled by the steam having cooled the blade ring and, moreover, the steam before entering the transition piece cools the first stage stationary blade 1C as well. Hence, the cooling effect is enhanced and the gas turbine performance is also enhanced.

[0065] Fig. 15 is a constructional view of a gas turbine of a fifth embodiment according to the present invention. If the fifth embodiment is compared with the fourth embodiment shown in Fig. 14, while in the fourth embodiment, cooling of the blade ring 60 and the stationary blade 1C and that of the transition piece are done sequentially in series, in the present fifth embodiment, cooling of the blade ring 60 and the stationary blade 1C and that of the transition piece are done in parallel and other portions of the construction are same as those of the fourth embodiment of Fig. 14.

[0066] That is, in Fig. 15, cooling steam enters the blade ring 60 via the passage 61 for cooling the portion 60a of the blade ring 60 and then enters the stationary blade 1C for cooling thereof via the passage 62 and the steam having cooled the stationary blade 1C is recovered via a passage 63'. At the same time, the steam bifurcates from the passage 61 to enter the transition piece for cooling thereof via a passage 65 and is then recovered via a passage 66. Thus, cooling of the blade ring 60 and the stationary blade 1C and that of the transition piece are carried out in parallel. In the so constructed fifth embodiment also, the same effect as that of the fourth embodiment can be obtained.

[0067] Next, a clearance control system applicable to the first to fifth embodiments according to the present invention will be described with reference to Figs. 16 to 19. Fig. 16 is a view showing clearance characteristic curves, wherein (X) shows the clearance characteristic curve when the clearance control system of the present

invention is applied and (Y) shows the clearance characteristic curve in the prior art. In the curve of (Y) of the conventional case, the initial clearance CR1 is 5 mm at a cold start time and 3 mm at a hot start time and also the minimum clearance CR2 at time T_1 is 3 mm at the cold start time and 0.8 mm at the hot start time.

[0068] At the rise time of the operation, while the blade ring is cold, the moving blade is heated earlier so as to make a larger thermal elongation and the clearance is reduced so that the minimum clearance CR2 occurs at the time T_1. In the characteristic curve (Y) of the conventional case, if the initial clearance CR1 is too small, then there occurs a contact in the minimum clearance CR2 at the time T_1 so as to cause a dangerous state and hence the initial clearance CR1 must be set with a certain allowance. In the conventional characteristic curve (Y), as the clearance increases in the operation, as shown in Fig. 16, if the initial clearance is made too large, then the clearance in the operation will become too large so that the gas turbine performance may be reduced.

[0069] On the contrary, in the characteristic curve (X) of the present invention, the blade ring is also heated at the rise time by steam of the auxiliary boiler, as shown in Fig. 1, so as to make a thermal elongation and the initial clearance also becomes large. Hence, the minimum clearance at the time T_1 becomes large, so that the risk of contact can be avoided. In operation, as described above with respect to the first to fifth embodiments, the blade ring is cooled by steam and the temperature, pressure and flow rate of the steam are controlled, as described later, so that the clearance may be set to an optimal target value CR0, which takes account of a safety and thereby the operation is done with the optimal clearance CR0 being maintained and the gas turbine performance is prevented from being reduced.

[0070] Fig. 17 is a cross sectional view of a gap sensor applicable to the clearance control system of the blade ring described with respect to Fig. 16. In Fig. 17, a gap sensor 70 is inserted from outside of the turbine casing 40 to pass through the turbine casing 40 and the blade ring 30 and to be fitted so that a sensing portion of the gap sensor 70 may be exposed on a surface of a shroud 30a on the first stage moving blade side. The gap sensor 70 is an FM (frequency modulation) electrostatic capacity type sensor and has a measuring performance up to the maximum usable temperature of 1200°C with an error of about 0.1 mm for the measuring range of 0 to 5.5 mm.

[0071] Fig. 18 is a front view of the turbine casing and the blade ring, wherein each of the partially cut out portions shows a cross sectional view taken on line A-A of Fig. 17. As shown in Fig. 18, four pieces of the gap sensors 70 are inserted from outside of the turbine casing 40 to pass through the turbine casing 40 and the blade ring 30 and the sensing portion of the gap sensor 70 is exposed on the surface of the shroud 30a of the blade ring 30, which confronts the first stage moving blade, and thereby the gap at the moving blade tip is detected at four places and the vertical directional and horizontal directional gaps of the blade ring are measured by the so detected four values, so that the characteristic curve as shown in Fig. 16 can be obtained. It is to be noted that such measuring is likewise carried out on the gap at the second stage moving blade tip.

[0072] Fig. 19 is a control diagram of the clearance control system applicable to the first to fifth embodiments according to the present invention. In Fig. 19, steam coming from the steam turbine bottoming cycle 10 has its temperature controlled by a temperature controller 72 and has its pressure and flow rate controlled by a flow control valve 71 and then flows into the blade ring 30 for cooling thereof through upper and lower two steam inlets of the blade ring 30. The steam having cooled the blade ring 30 flows out of four steam outlets of the blade ring 30 to be recovered into the steam turbine bottoming cycle 10. Also, in the blade ring 30, there are provided the four gap sensors 70, as shown in Fig. 18, and thereby the clearance at the moving blade tip is measured and the signal thereof is inputted into a control unit 73.

[0073] The control unit 73 takes the signal from the gap sensor 70 and when the time T_1 in the rise time, as shown in Fig. 16, has passed, the control unit 73 compares the signal with the optimal target value of the clearance, which is stored in advance, and thereby the opening of the flow control valve 71 and thus the pressure and flow rate of the steam are controlled so that the clearance approaches to the target value as well as the temperature controller 72 and thus the temperature of the steam are likewise controlled.

[0074] By controlling the temperature, pressure and flow rate of the steam at the control unit 73, conditions of the steam-cooling of the blade ring are variously changed so that the clearance may be approached to the optimal target value, as shown in Fig. 16, and thereby the clearance can be set as small as possible and reduction in the gas turbine performance due to enlargement of the clearance can be prevented.

[0075] While the preferred forms of the present invention have been described, it is to be understood that the invention is not limited to the particular constructions and arrangements herein illustrated and described but embraces such modified forms thereof as come within the scope of the appended claims.

Claims

1. A gas turbine comprising a moving blade and a blade ring confronting a tip of said moving blade, **characterized in that** a cooling passage (8) is provided in said blade ring and an auxiliary boiler (11) and a steam supply source connecting to a steam turbine bottoming cycle (10) are connected to said cooling passage (8), so that steam of said auxiliary

boiler (11) or said steam supply source is flown into said cooling passage (8) for cooling said blade ring and the steam having cooled said blade ring is recovered, and thereby a clearance between said tip of the moving blade and said blade ring is reduced.

2. A gas turbine comprising a moving blade (1S) and a blade ring (20) confronting a tip of said moving blade (1S) as well as comprising a combustor (3) and a transition piece contained in said combustor (3), **characterized in that** a cooling passage (8) is provided in said blade ring (20), so that steam of a steam supply source is flown into said cooling passage (8) for cooling said blade ring (20) and the steam having cooled said blade ring (20) is flown into said transition piece via a combustor transition piece connection portion (23) for cooling a wall interior of said transition piece and the steam having cooled said wall interior of the transition piece is recovered into said steam supply source, and thereby a clearance between said tip of the moving blade (1S) and said blade ring (20) is reduced.

3. A gas turbine comprising a moving blade and a blade ring confronting a tip of said moving blade as well as comprising a combustor (3) and a transition piece contained in said combustor (3), **characterized in that** a cooling passage (8) is provided in said blade ring, so that steam of a steam supply source is flown in parallel into said cooling passage (8) for cooling said blade ring and into said transition piece via a combustor transition piece connection portion for cooling a wall interior of said transition piece and the steam having cooled said blade ring and said wall interior of the transition piece is recovered into said steam supply source, and thereby a clearance between said tip of the moving blade and said blade ring is reduced.

4. A gas turbine comprising a first stage stationary blade (1C) and a first stage moving blade (1S) and a blade ring (60, 60a) confronting a tip of said first stage moving blade (1S) as well as comprising a combustor (3) and a transition piece contained in said combustor (3), **characterized in that** a blade ring cooling passage (61) is provided in said blade ring (60, 60a) and a stationary blade cooling passage (62, 63) is provided in said first stage stationary blade (1C) so as to connect to said blade ring cooling passage (61), so that steam of a steam supply source is flown into said blade ring cooling passage (61) for cooling said blade ring (60, 60a) and the steam having cooled said blade ring (60, 60a) is flown into said stationary blade cooling passage (62, 63) for cooling said first stage stationary blade (1C) and the steam having cooled said first stage stationary blade (1C) is flown into said transition piece via a combustor transition piece connection portion for cooling a wall interior of said transition piece and the steam having cooled said wall interior of the transition piece is recovered into said steam supply source, and thereby a clearance between said tip of the first stage moving blade (1S) and said blade ring (60, 60a) is reduced.

5. A gas turbine comprising a first stage stationary blade (1C) and a first stage moving blade (1S) and a blade ring (60, 60a) confronting a tip of said first stage moving blade (1C) as well as comprising a combustor (3) and a transition piece contained in said combustor (3), **characterized in that** a blade ring cooling passage (61) is provided in said blade ring (60, 60a) and a stationary blade cooling passage (62, 63') is provided in said first stage stationary blade (1C) so as to connect to said blade ring cooling passage (61), so that steam of a steam supply source is flown in parallel into said blade ring cooling passage (61) for cooling said blade ring (60, 60a) and into said stationary blade cooling passage (62, 63') for cooling said first stage stationary blade (1C) and the steam having cooled said first stage stationary blade (1C) is flown into said transition piece via a combustor transition piece connection portion for cooling a wall interior of said transition piece and the steam having cooled said blade ring (60, 60a) and said wall interior of the transition piece is recovered into said steam supply source, and thereby a clearance between said tip of the first stage moving blade (1S) and said blade ring (60, 60a) is reduced.

6. A gas turbine as claimed in Claim 2, **characterized in that** said blade ring (20) is a blade ring confronting a tip of a first stage moving blade (1S), said combustor (3) is a plurality of combustors arranged in a turbine circumferential direction, there are provided in said blade ring (20) a plurality of blocks (22) protruding in a turbine axial direction from positions of said blade ring corresponding to positions of said plurality of combustors (3) and, in each of said plurality of blocks (22), there is provided a U-shape passage (8, 8a, 8b) formed by turbine axial directional and circumferential directional passages, so that steam is flown into said U-shape passage (8, 8a, 8b) from one end of said U-shape passage (8, 8a, 8b) for cooling said blade ring (20) and is flown out of the other end of said U-shape passage, and the steam having cooled said blade ring (20) is supplied into said transition piece via said combustor transition piece connection portion.

7. A gas turbine as claimed in Claim 2, **characterized in that** said blade ring comprises a first blade ring (30) confronting a first stage moving blade (1S) and a second blade ring (31) confronting a second stage moving blade (2S), said cooling passage comprises

a first cooling passage (35) formed in said first blade ring (30) and a second cooling passage (36) formed in said second blade ring (31) and there are provided a turbine axial directional passage for connecting said first and second cooling passages (35, 36) to each other and a transition piece side passage for connecting said first cooling passage (35) and said combustor transition piece connection portion to each other, so that the steam of said steam supply source is flown sequentially in said second cooling passage (36), turbine axial directional passage, first cooling passage (35) and transition piece side passage and is then supplied to said combustor transition piece connection portion.

8. A gas turbine as claimed in Claim 7, **characterized in that** said combustor transition piece connection portion comprises a transition piece cooling inlet (32) connecting to said first cooling passage (35), a transition piece cooling outlet (33) through which the steam having cooled said transition piece flows out and an outlet pipe manifold (34) connecting to said transition piece cooling outlet (33).

9. A gas turbine as claimed in Claim 7, **characterized in that** each of said first and second blade rings (30, 31) is formed such that upper and lower two separated semicircular portions of the blade ring (30, 31) are joined together at flanges (41) provided on both side surface portions of the blade ring (30, 31), there are provided a recessed portion (31a) or a protruded portion on an outer circumferential surface portion of the blade ring so as to fit to or fit in a portion of a turbine casing inner wall and another protruded portion (31b) on an inner circumferential surface portion of the blade ring (30, 31) so as to support a wall surface confronting said tip of the moving blade (1S, 2S) and a turbine axial directional cross sectional shape of the blade ring (30, 31) is approximately symmetrical relative to a turbine radial directional central axis in said turbine axial directional cross sectional shape of the blade ring (30, 31).

10. A gas turbine as claimed in Claim 7, **characterized in that** each of said first and second blade rings (30, 31) is formed such that upper and lower two separated semicircular portions of the blade ring (30, 31) are joined together at flanges (41) provided on both side surface portions of the blade ring (30, 31) and, in horizontal surface portions of said upper and lower semicircular portions of the blade ring (30, 31) so joined at said flanges (41), the cooling passage provided in said upper semicircular portion of the blade ring (30, 31) is extended so as to be inserted with a predetermined length into the cooling passage provided in said lower semicircular portion of the blade ring (30, 31) and a sealing material (43) is interposed around the cooling passage so extended of said upper semicircular portion of the blade ring (30, 31).

11. A gas turbine as claimed in any one of Claims 1 to 5, **characterlz d in that** said blade ring (30, 31) is formed such that upper and lower two separated semicircular portions of said blade ring (30, 31) are joined together at flanges (41) provided on both side surface portions of said blade ring (30, 31) and there are provided members (44), having masses substantially equivalent to said flanges (41) thermally, on upper and lower portions of an outer circumferential surface portion of said blade ring (30, 31).

12. A gas turbine as claimed in any one of Claims 1 to 5, **characterized in that** said blade ring (30, 31) is provided with a plurality of steam inlets (45-1, 45-2, 47-1, 47-2, 47-3) and steam outlets (46-1, 46-2, 46-3, 46-4, 48-1, 48-2, 48-3), respectively, arranged substantially evenly in vertical and horizontal directions on an outer circumferential surface portion of said blade ring (30, 31).

13. A gas turbine as claimed in Claim 7, **characterized in that** said blade ring (30, 31) is applied to on its surface exposed to a high temperature space with a thermal shield (37) made of a heat insulation material (49).

14. A gas turbine as claimed in any one of Claims 1 to 5, **characterized in that** said blade ring (20, 30, 31, 60) is provided therein with a plurality of sensors (70) for sensing said clearance at the tip of the moving blade (1S, 2S), said sensors (70) being inserted from outside of a turbine casing (40) to pass through said turbine casing (40) and said blade ring (20, 30, 31, 60) so that sensing portions of said sensors (70) may be exposed on an inner circumferential wall surface confronting said tip of the moving blade (1S, 2S), and there are provided a steam temperature controller (72) arranged in a route for supplying said blade ring (20, 30, 31, 60) with steam from said steam supply source, a steam flow control valve (71) arranged between said steam temperature controller (72) and a steam inlet of said blade ring (20, 30, 31, 60) and a control unit (73) taking signals from said sensors for comparison with a predetermined target value and controlling said steam temperature controller (72) and an opening of said steam flow control valve (71) so that said clearance may be approached to said target value.

15. A gas turbine as claimed in Claim 14, **characterized in that** said sensors (70) are FM electrostatic capacity type sensors.

Fig. 1

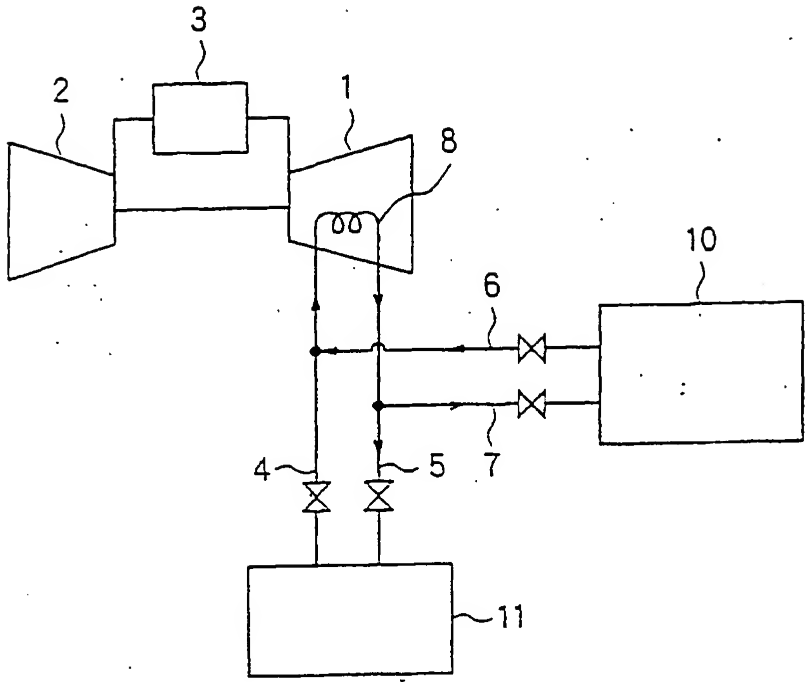


Fig. 2

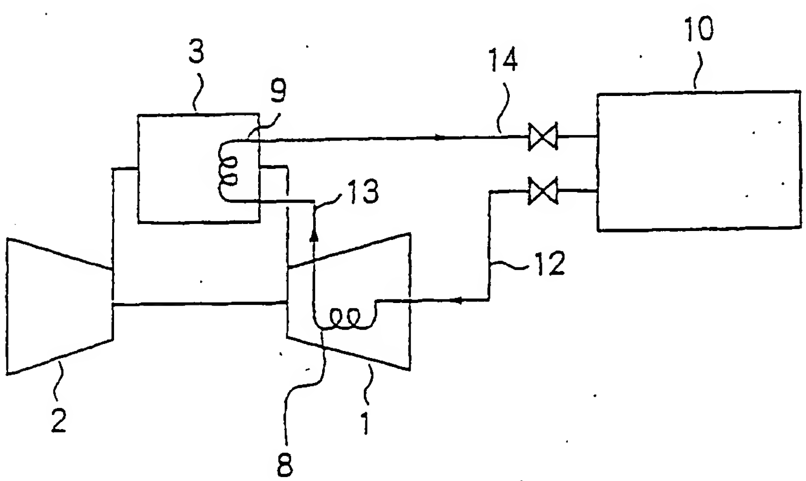
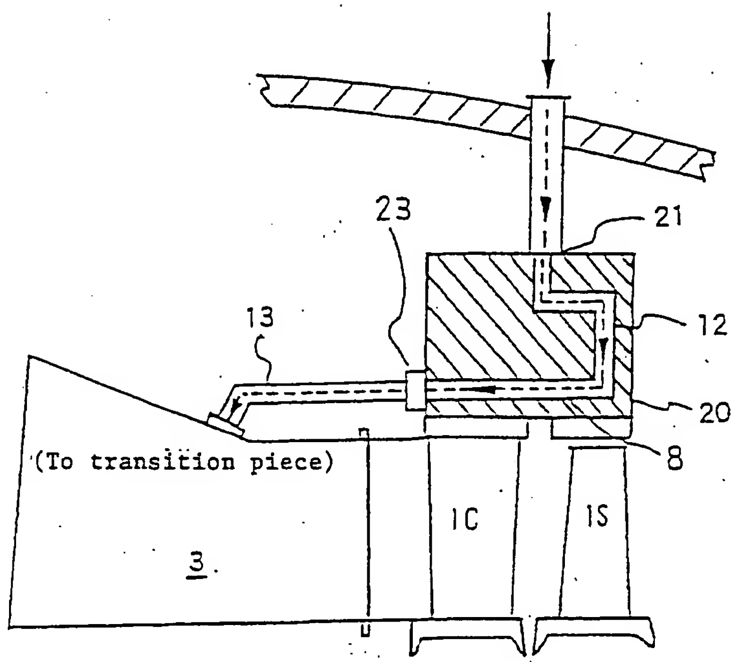


Fig. 3



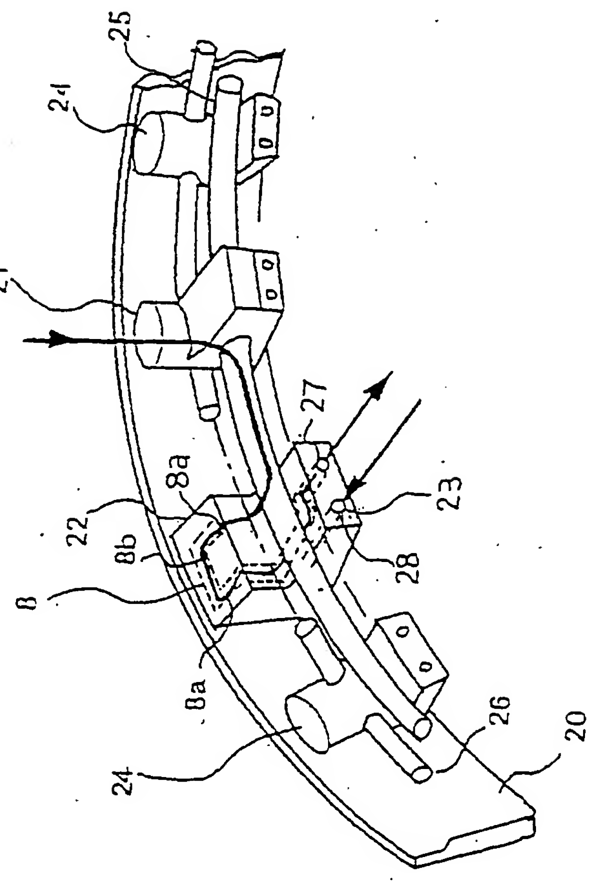


Fig. 4

Fig. 5

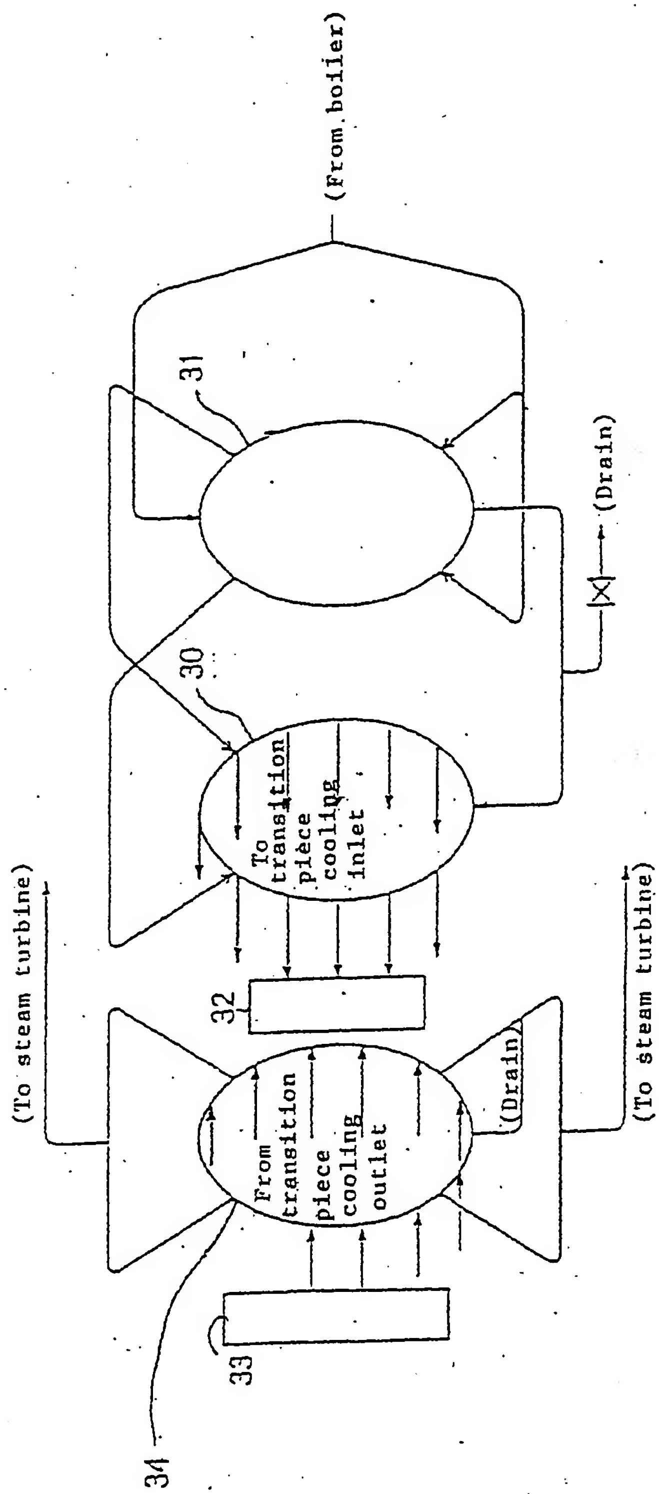

(From boiler)
31
(Drain)
30
To transition piece cooling inlet
(To steam turbine)
32
From transition piece cooling outlet
(Drain)
(To steam turbine)
33
34

Fig. 6

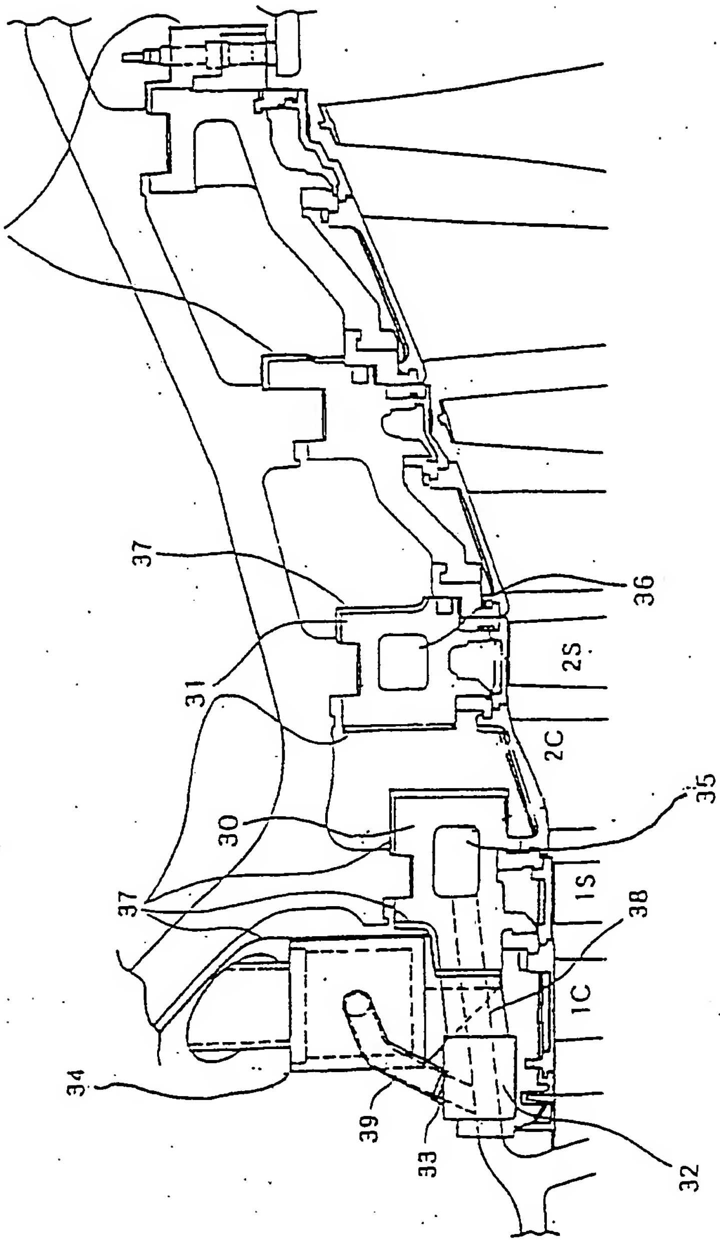


Fig. 7

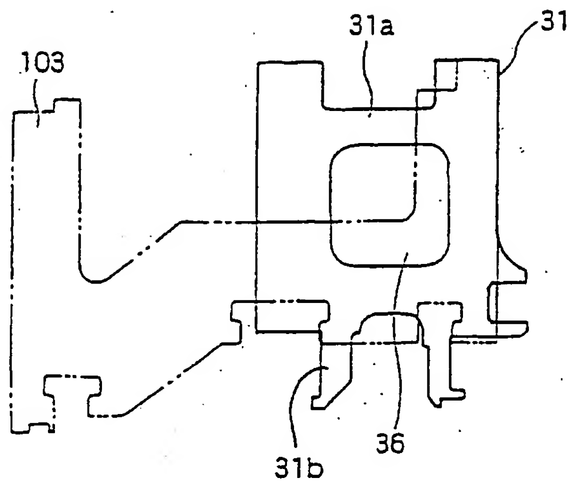


Fig. 8

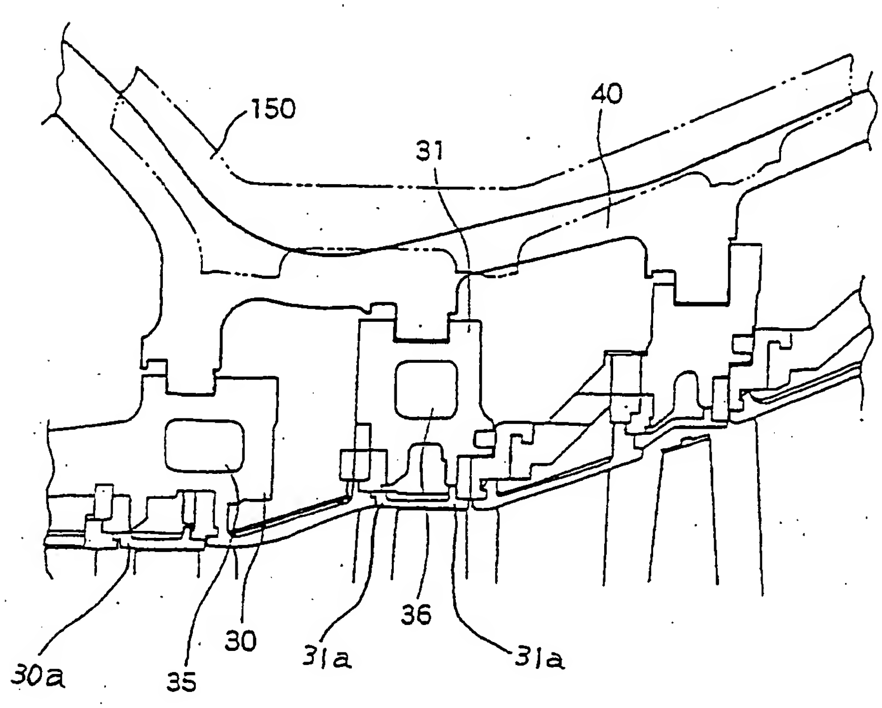


Fig. 9 (a) Fig. 9 (b)

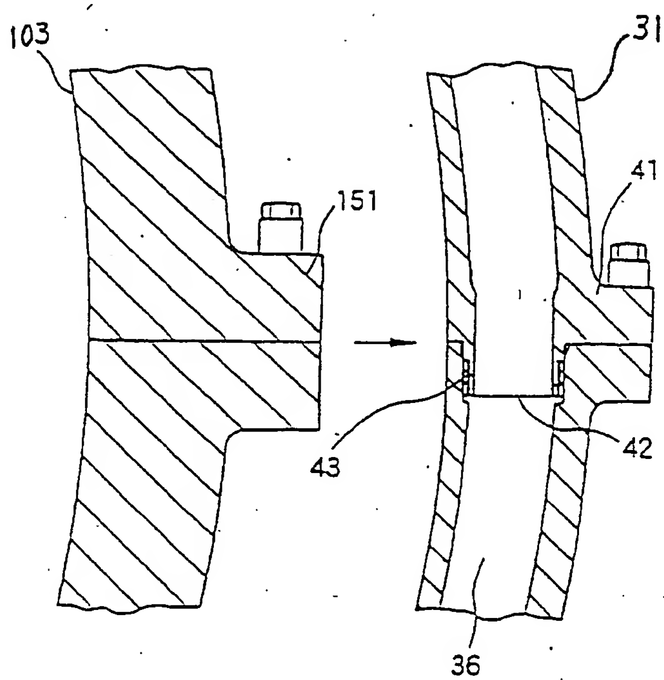


Fig. 10(a)

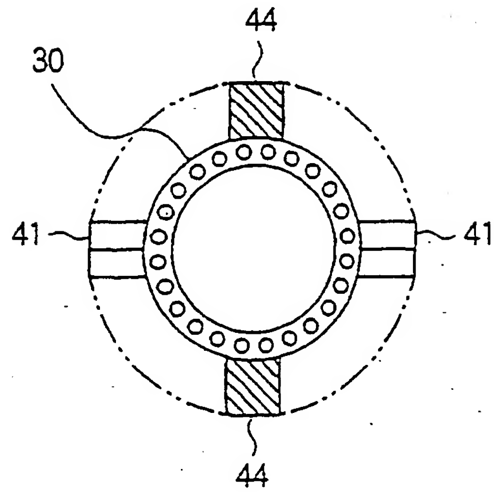


Fig. 10(b)

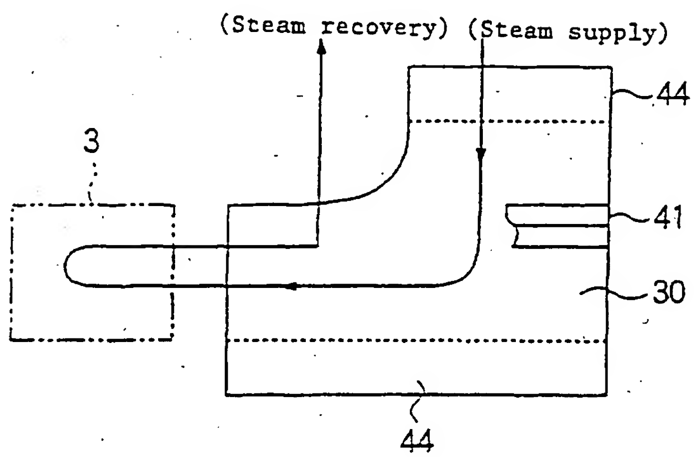


Fig. 11(a)

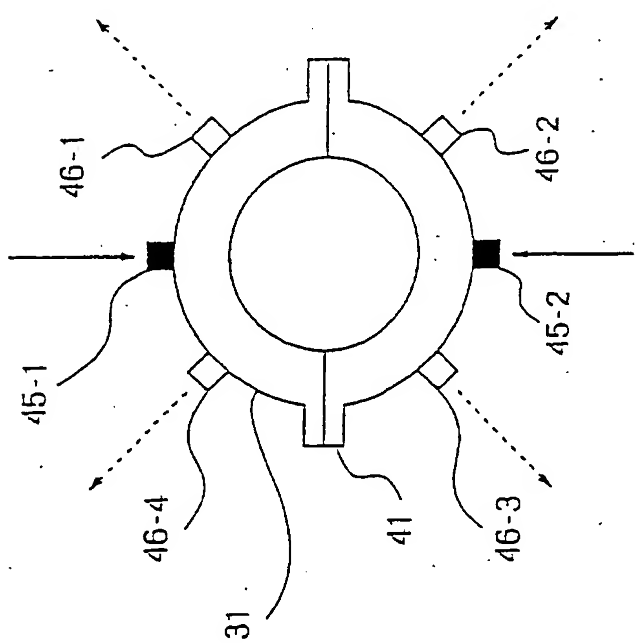


Fig. 11(b)

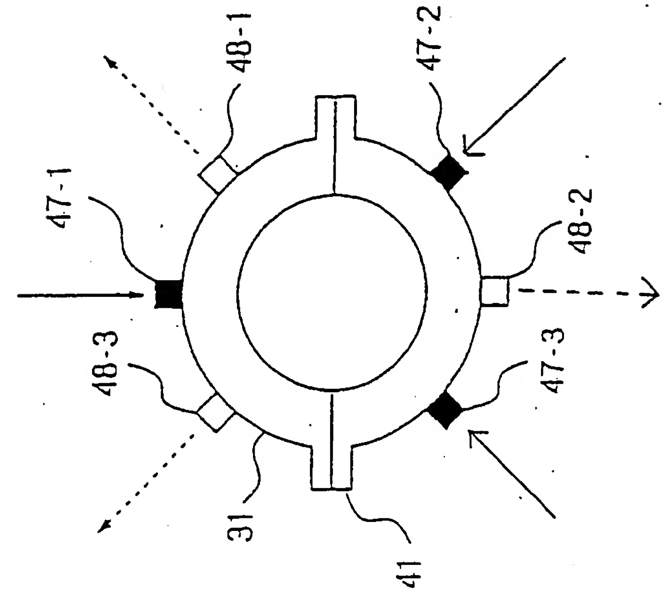


Fig. 12

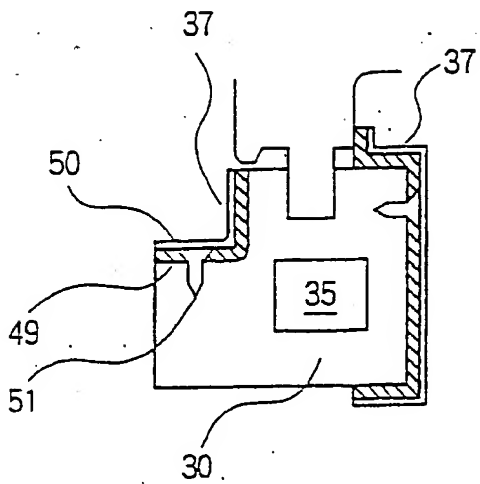


Fig. 13

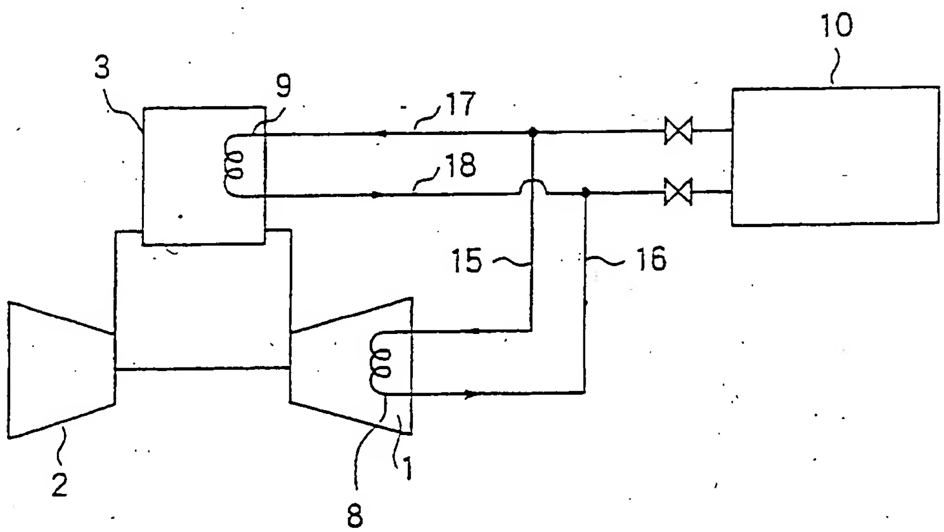


Fig. 14

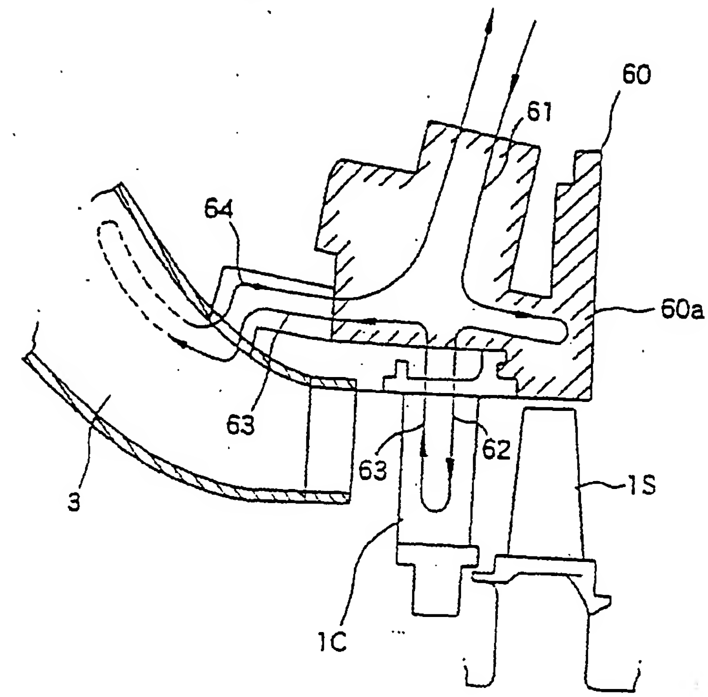


Fig. 15

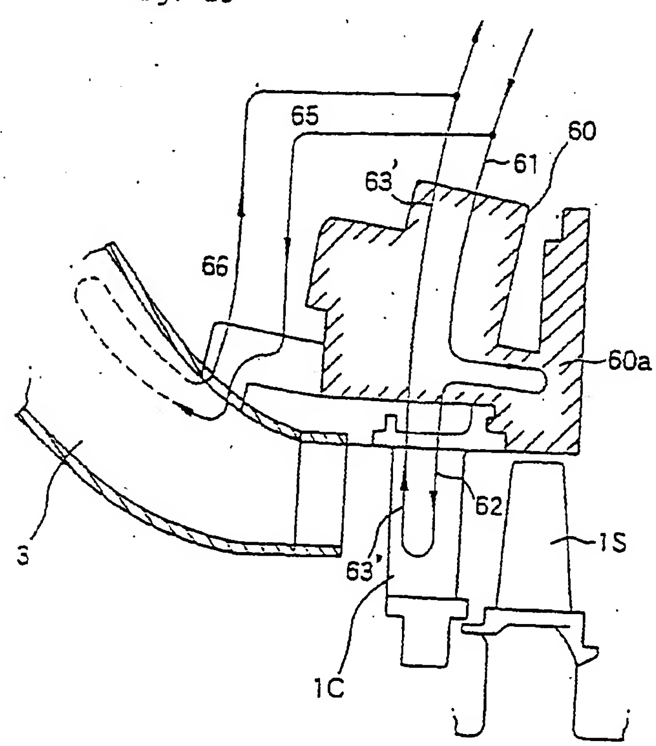


Fig. 16

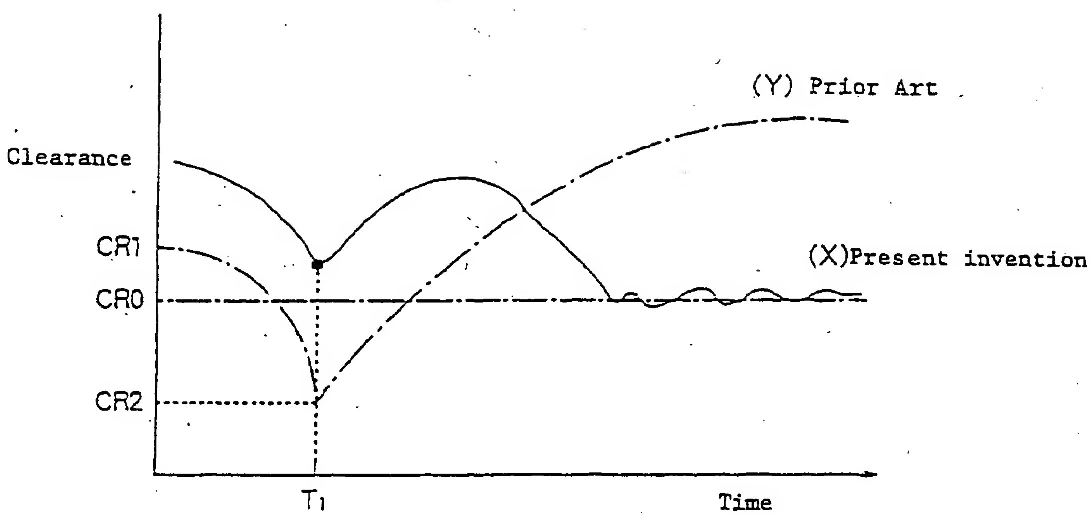
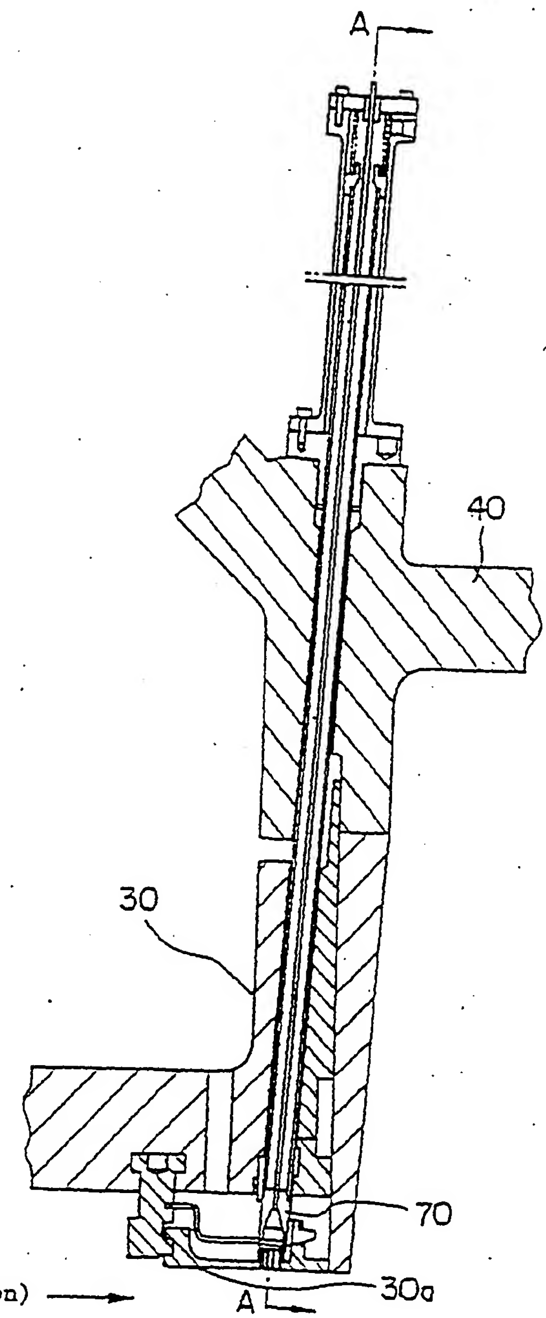
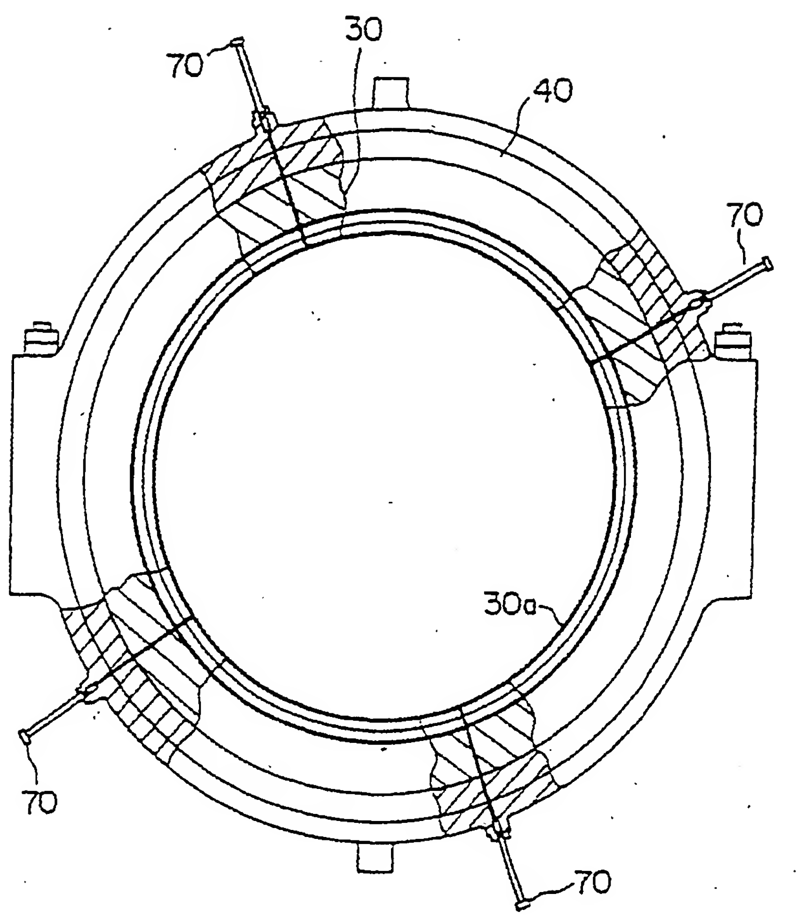

(Y) Prior Art
Clearance
CR1
CR0
CR2
(X)Present invention
T1
Time

Fig. 17



(Gas flow direction)

Fig. 18



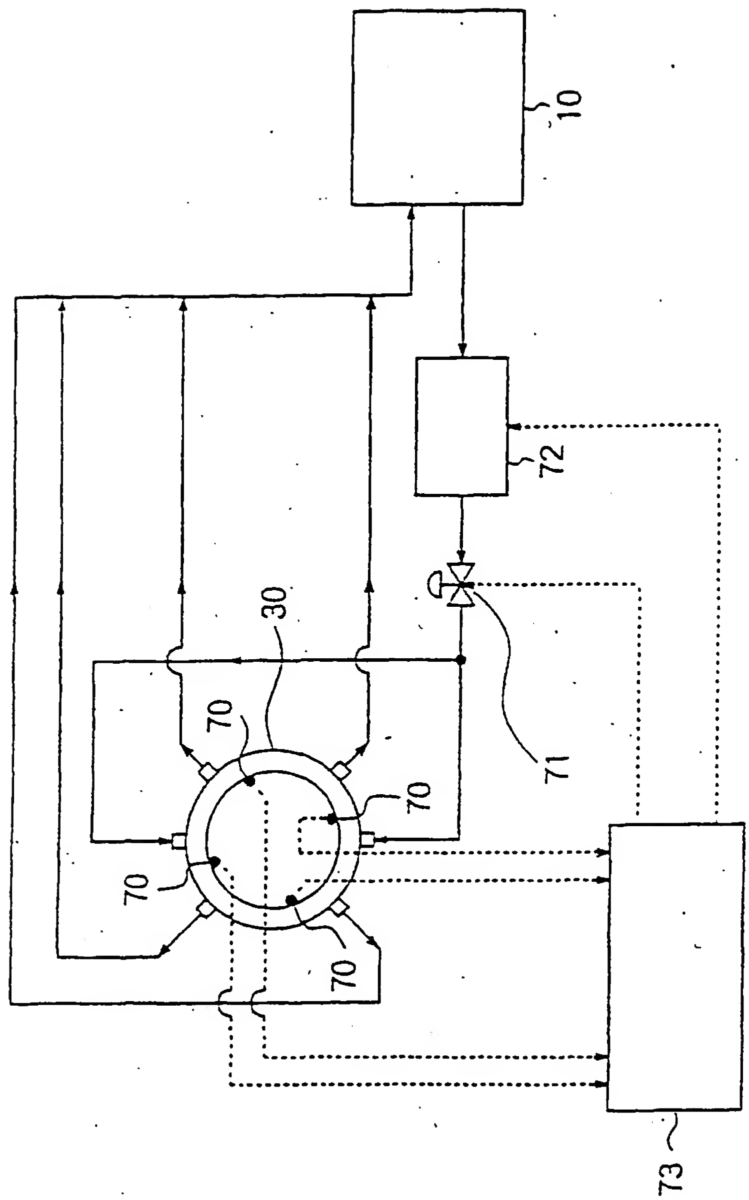


Fig. 19

Fig. 20